Forests and Carbon: Trends and Data for the U.S.

Christopher Woodall*

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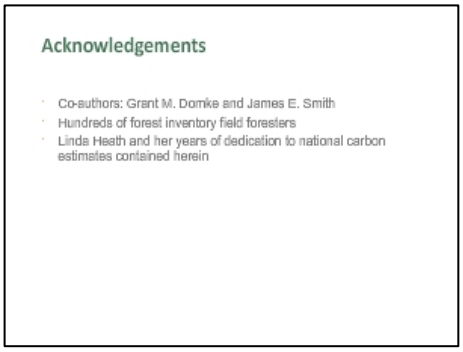
Slide 1. Forests: Trends and data for the U.S.

Hi, my name is Chris Woodall. I'm research forester at the Forest Inventory and Analysis unit with the U.S. Forest Service, Northern Research Station in St. Paul, Minnesota. Today I'm going to talk about forests and carbon trends and data for the United States, so broadly looking at carbon estimates and trends for the entire nation.

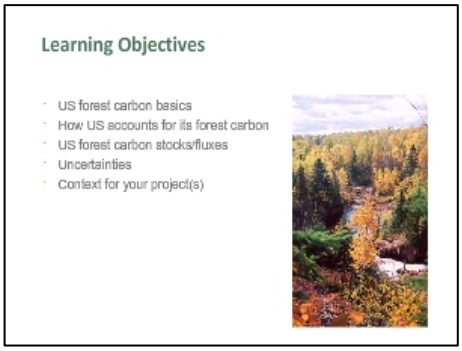
Slide 2. Acknowledgments

I'd like to acknowledge a number of my coauthors, Grant Domke and Jim Smith with my same program. I'd also like to acknowledge the hundreds of forest inventory field foresters who have collected this data across the country over many decades. Linda Heath, I'd like to acknowledge and her years of dedication to these estimates.



Slide 3. Learning Objectives

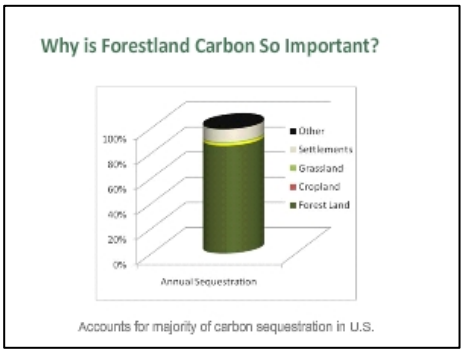
So as far as objectives for today, I'd like to broadly talk about U.S. forest carbon basics, the context of why we do this, how the U.S. accounts for its forest carbon and the methods, go over some of the results as far as forest carbon stocks and fluxes, and discuss some of the uncertainties associated with those estimates, and touch on the context as far as those estimates and your project that you might have on a smaller scale.



** This document transcribes the presentation given by Dr. Woodall. The presentation is part of General Technical Report NRS-93, "Forest and grassland carbon in North America: A short course for land managers." The full report, comprised of 15 presentations, is in DVD format and can be obtained at http://nrs.fs.fed.us/pubs/order/40110. The presentations and related materials can also be accessed at http://www.fs.fed.us/ccrc/carboncourse/*

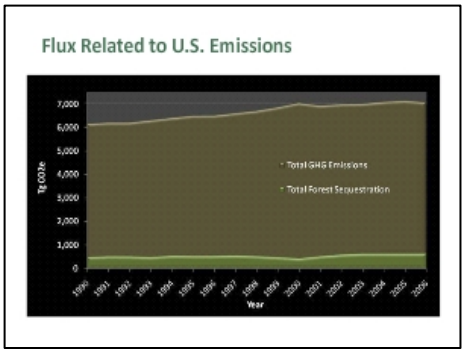
Slide 4. Why is Forestland Carbon So Important?

So why is forestland carbon so important? Why do we take all the effort to monitor it and report on it across the United States? Well, it accounts for the majority of carbon sequestration in the U.S. compared to other land uses such as settlements, the urban areas, grasslands, croplands. Over 70 percent of annual sequestration as far as greenhouse gases being taken out of the air occur from the forestland use sector.



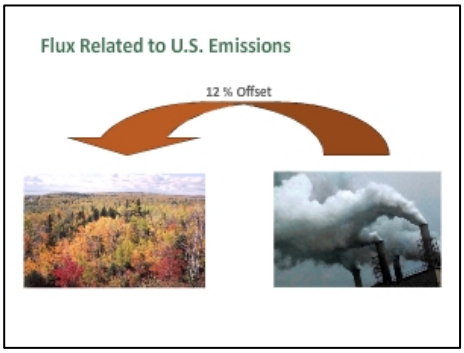
Slide 5. Flux Related to U.S. Emissions

Now in the context of total greenhouse gas emissions in the U.S., it is still dwarfed by all the emissions from tailpipes, et cetera, in the United States. Across time, forest carbon sequestration has been fairly steady in face of a slightly increasing greenhouse gas emission over time since 1990 in the United States.



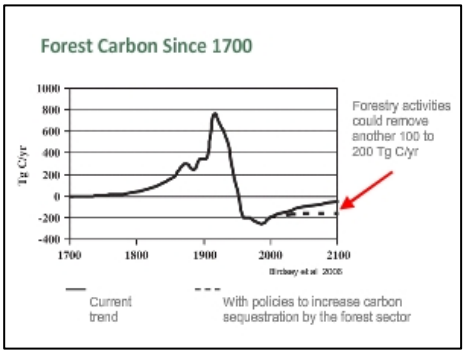
Slide 6. Twelve Percent Offset

That adds up to about a 12 percent offset annually in the United States. As far as taking emissions, greenhouse gas emissions, and putting them back into forests, it's about a 12 percent offset annually. So the largest land use as far as offset, and very important to monitor and manage our forest in that context.

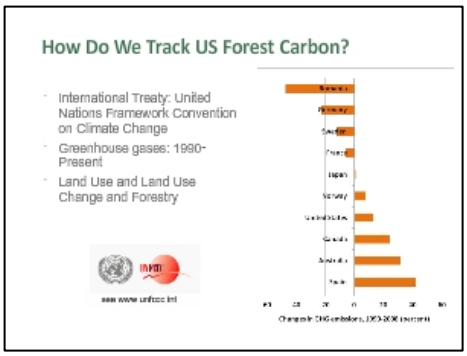


Slide 7. Forest Carbon Since 1700

As far as being a unique ecosystem service, forests have not always been a net sequesterer as far as taking carbon out of the atmosphere. You've seen in a previous talk, other regions of the world forests can be a net emitter of carbon, and in the U.S. in the past, forests have been a net emitter due to active logging utilization hundreds of years ago. Although over the past century forests have been a net sequesterer of carbon due to reforestation, afforestation, active forest management doing a good job of sustainably managing our forests as a whole across the U.S., we are a net sequesterer now of carbon. Now you'll see other talks later on discussing forest management opportunities to increase or possibly decrease forest carbon stocks, so it's still a question as to where do we head in the future, and foresters play a role in that.

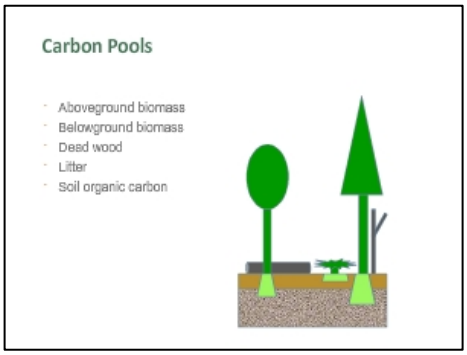


Slide 8. How Do We Track US Forest Carbon?



So how do we track forest carbon? The U.S. is a signatory to the United Nations Framework on Climate Change as far as broadly setting up the methodology for estimating a nation's forest carbon. One of the precedents with that agreement is that we had a 1990 baseline, so we report our greenhouses gases from a 1990 place in time. And forestry is in a sector called land use and land use change in forestry, which you may see mentioned in subsequent talks. What this allows us to compare our estimates on the same kind of framework to other nations around the world to see how we're doing as far as carbon stocks and fluxes.

Slide 9. Carbon Pools

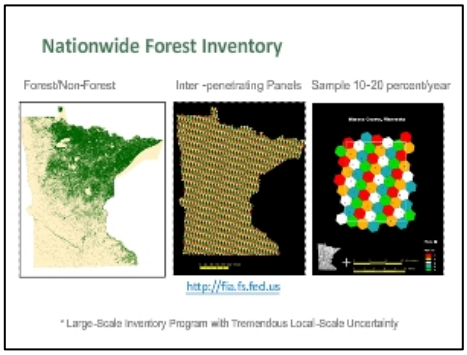


So carbon pools as defined broadly and internationally are aboveground biomass, belowground biomass, dead wood, which can be standing dead or down dead, litter is what you'd find on the forest floor with leaf fall and fine woody debris and some of the duff layers, and then soil organic carbon. And you'll hear a lot about soils later on due to its importance.

Slide 10. National Accounting Workflow

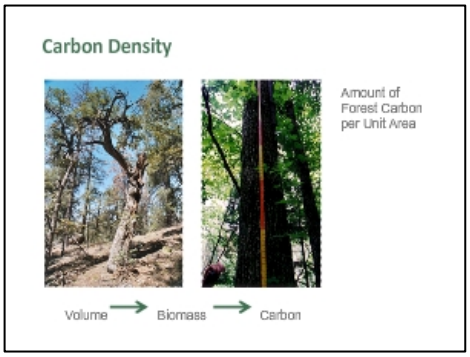
National accounting workflow, the first thing we do is estimate land uses, and that's determining where the forests are across the U.S. compared to agricultural grassland areas so we don't double count areas in the total stock estimates. The second step is to estimate carbon density. That's where foresters actually go out there and measure trees on a particular unit of land, and then we estimate flux through stock change.

Slide 11. Nationwide Forest Inventory



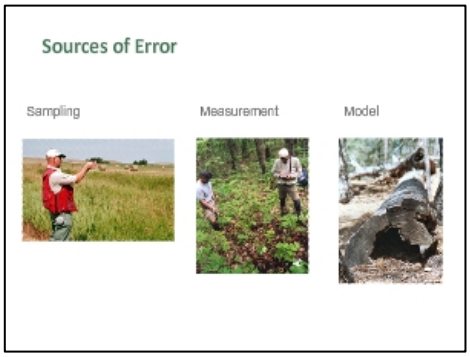
Now as far as the carbon density, we use a nationwide forest inventory from the Forest Inventory and Analysis Program where we broadly place plots in hexagonal pattern across the country and send field crews out there to actually measure the trees on those plots. Very traditional forest inventory in that sense. We sample 10 to 20 percent of those plots annually per year so we get an idea of a rolling average of forest attributes across the country. Now I must make a note that this large scale forest inventory has tremendous local scale uncertainty, but at a national scale can broadly provide carbon density estimates and ideas of where the forest is and isn't across the U.S. over time.

Slide 12. Carbon Density



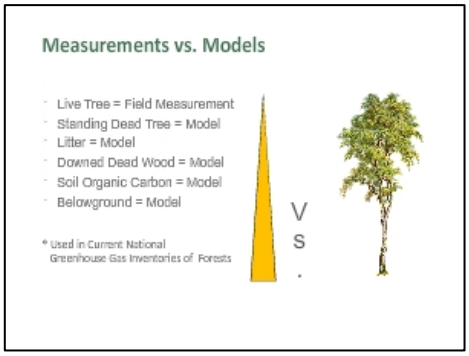
So carbon density, our field crews go out there and measure DBH[1] and height, what we've done for many decades or centuries, and turn that into volume. And from that we can allocate that to various biomass components such as crown bowl, roots belowground, and get an estimate of the amount of forest carbon per unit area and we can turn that then into national estimates.

Slide 13. Sources of Error



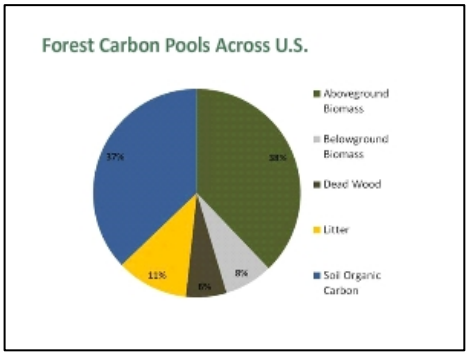
There are a lot of sources of error to consider which are applicable at the national scale, and definitely even at the local or regional smaller scales such as sampling error, are we actually finding the forest out there on the landscape, measurement error, are forester doing a good job of measuring DBH, and model error is for instance, with this piece of coarse woody debris are we adequately modeling the interior missing biomass and the volume of that piece? So those are areas of research and uncertainty that should be looked at.

Slide 14. Measurements vs. Models



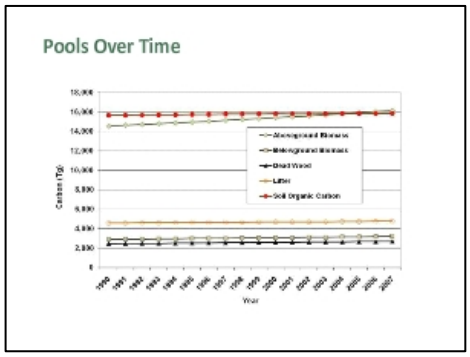
Now for the national greenhouse gas inventory, and this is at the national scale. Currently our live tree estimates are based heavily on field measurements of the DBH, height, species, et cetera. All the other pools, the stocks that we look at, are more based on models, which can be based a lot on the field measurements of live trees, but there's still a lot of models such as standing dead trees, litter, soil organic carbon, belowground. They can perhaps be based on the stocking of live trees and the forest type in that stand, but they're still heavily modeled right now. We'd like to improve on that in the future and I'll touch on that later.

Slide 15. Forest Carbon Pools Across U.S.



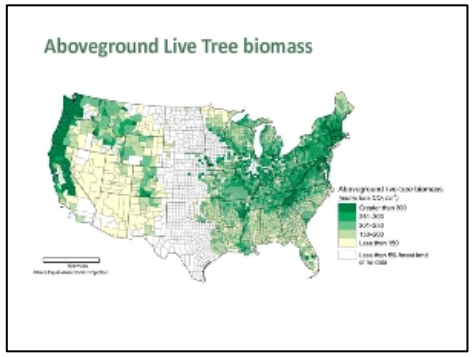
Looking at the results moving from the explanation of our methodologies, most of the carbon stocks across the U.S. are in aboveground biomass and that makes sense for forest ecosystems. That's followed up by 37 percent of total stocks being soil organic carbon, so the soils across the U.S. in our forests, and that's followed up in third place by litter at 11 percent.

Slide 16. Pools Over Time



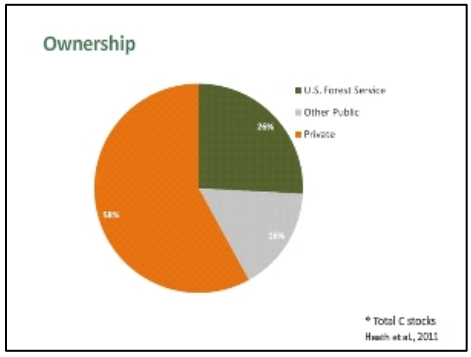
Now these pools over time appear fairly steady and that is based on the modeling off of our aboveground biomass. So our aboveground biomass has been fairly steady, which is really up at the top of the graph followed closely by the soil organic carbon, which you see in red dots. It's been fairly steady since 1990 and that can be quite a different picture at smaller local scales. We have a lot more variability. That's why you see a lot of the trending of things being fairly static over time is that dependency on the live tree attributes that drive the other carbon pool models.

Slide 17. Aboveground Live Tree Biomass



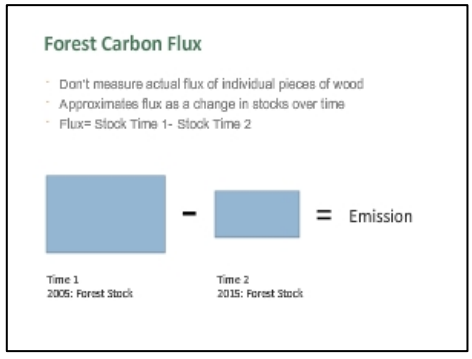
Spatially how do we see carbon stocks as far as aboveground live tree biomass across the U.S.? Well, it's heavily centered on the West Coast and Appalachian Mountains, central hardwood areas, New England, kind of where you expect to find your forest area. Well, that's where you find your aboveground live tree biomass. There's a lot of variability when you get down to the county level, and even smaller scales such as stands or entity level.

Slide 18. Ownership



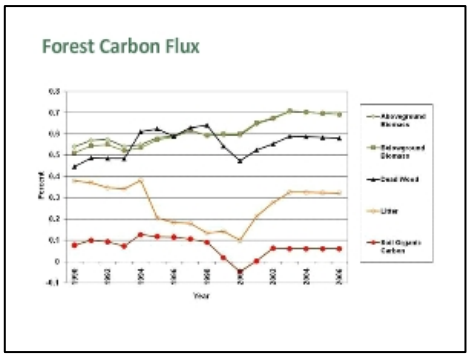
Who owns the carbon stocks, total carbon stocks across the U.S.? Private landowners do. Fifty-eight percent of our total carbon stocks are owned by private landowners in the United States followed up by the U.S. Forest Service at 26 percent. Now carbon densities can vary. Obviously the U.S. Forest Service has a lot of old growth and highly stocked stands which can have higher carbon density across the U.S., but just the broad allocation among landownership patterns.

Slide 19. Forest Carbon Flux



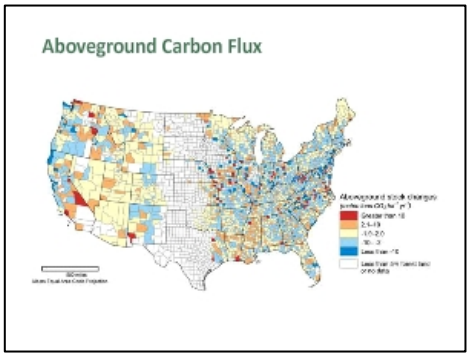
As far as carbon flux, we don't nationally go and check on the respiration of individual trees across the U.S. It's a stock change estimate. So you have foresters measure a stand at time one, come back manage the stand at time two, and you get a change estimate. So if you have more biomass perhaps at time two, then you might have had a net sequestration of carbon versus if you have less biomass, for example, you might have an emission over that time period.

Slide 20. Forest Carbon Flux



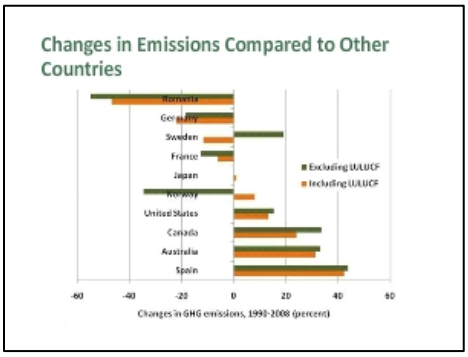
If we look broadly across time since 1990 in the U.S. as far as aboveground-belowground carbon flux of those pools as an annual percent, the things that changed the most or flux as far as sequestration remission, and here they're all sequestration, is aboveground biomass, followed by belowground biomass, and dead wood. So these things are really tied to what's growing dynamically, actively, annually in force. The thing that changes the least as far as annual flux is the soil, which is a slowly evolving carbon component. It's what you would expect to find.

Slide 21. Aboveground Carbon Flux



Looking at this once again at a county level across the United States is a lot of variability. And a lot of this, you have to look at uncertainty and your stocks, and in this figure red is an emission, so we're assuming that the stock change is less biomass, for example, at time two than time one, whereas a blue color is where there is more biomass, for example, at time two, and possibly a sequestration of carbon. So there's a lot of variability, and when you drill down to the local level we have to check out what your errors and uncertainty are.

Slide 22. Changes in Emissions Compared to Other Countries

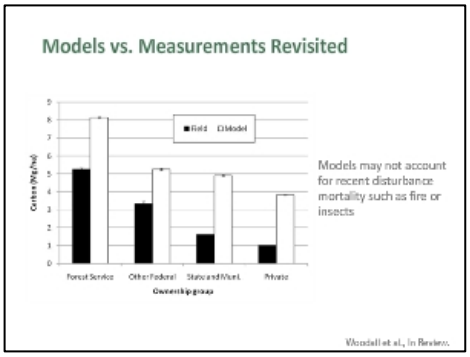


Now compared to other nations, I started out the beginning of the talk saying that we have these constructs that are internationally agreed upon so that we can compare things equally across the world. The United States along with many other countries is a net emitter of carbon when you look at all greenhouse gas emissions and sequestration. And in this figure you have the positive number is an emission to the atmosphere where a negative number is a sequestration. Here you can see whether it includes the land use and land use change in forestry, or excludes it. You see that 12 percent kind of an offset forests provide. You look at other nations such as Sweden which has a relatively large forest area compared to a smaller population and a very active forest management industry in that nation. Forest management makes a big difference for that country. They can go from being a net emitter of carbon to being a net sequesterer of carbon. So that should hold up in subsequent talks as far as the importance of forest management in this country.

Slide 23. Uncertainties

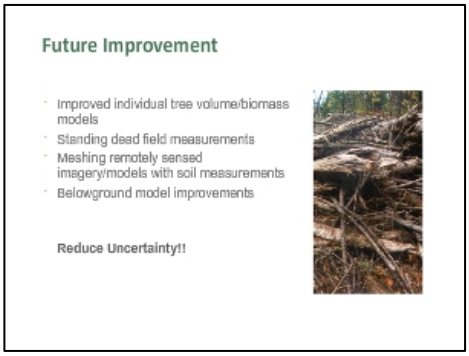
Now I just want to touch a bit on uncertainties. For example right here, standing live tree pool versus dead wood pool. As I touched on previously, standing live tree, we may know the most about as far as less uncertainty. It's a field based measurement, we have quality control, we can figure out how well a forester is managing those tree attributes versus the dead wood pool where often it is modeled such as it is now with the national greenhouse gas inventory. At your local small scale you may have anecdotal studies which may help you out in intensive research plots, but there's model error that needs to be incorporated that could be substantial, and these models may be insensitive to climate change events.

Slide 24. Models vs. Measurements Revisited



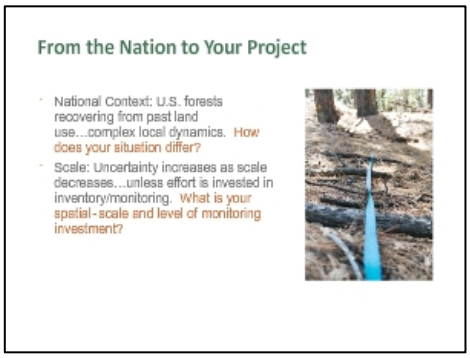
Just to revisit this a little bit more, this is a figure of the ratio of standing live trees to standing dead trees both by field and modeled across the U.S. on FIA[2] plots, and you see in the white columns here, the model says on average, regardless of ownership, there's about 10 to 12 standing live trees for every dead tree across the United States. If you look at the actual standing dead trees measured on those plots, there's quite a divergence. There's actually a lot less standing dead trees than the model is saying, but there's quite a divergence in ownership. Whereas in the East you have a lot of private ownership and a lot less standing dead, the ratio is upwards of 100:1. Whereas a lot of the western forests and the national forests out there have a lot of epidemics of bugs and weather events, you have ratios indicating a lot more standing dead. So trying to move toward more of a empirically-based approach will benefit our national carbon estimates.

Slide 25. Future Improvement



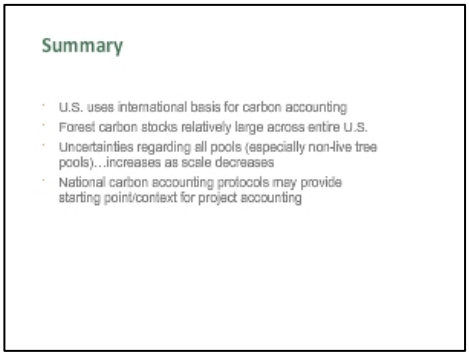
And these are part of the future improvements we'd like to incorporate to benefit and reduce uncertainties such as improve individual tree volume biomass models. We know a lot about ponderosa pine, but how about slippery elm? Try and incorporate our standing dead tree field measurements into our estimates to more relate to actual climate change events, which may be occurring across landscapes. Meshing remotely sensed imagery models with our soil measures, trying to do a better job with our soil inventory. And also belowground model improvements, because we don't actually measure roots, we model those. So it's all about reducing uncertainty.

Slide 26. From the Nation to Your Project



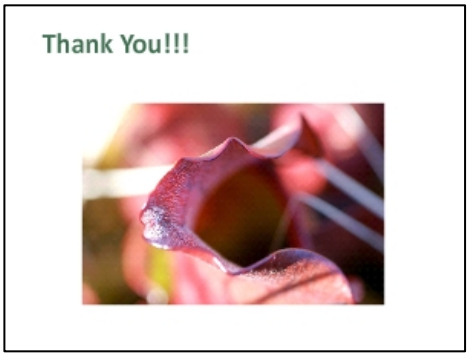
So from the nation to your project, this talk has provided a national context. You see forests in the U.S. are recovering from past land uses where they have complex local dynamics. So the question is how does your situation differ in your local area as far as land use history and those unique stand dynamics in your area? Also, scale is very important and you'll hear it in subsequent talks as far as uncertainty increasing as scale decreases, and that is unless you invest in your monitoring efforts. Forest inventory data at the national scales really can only be useful at a national scale, and it's hard to drill down to county level with that data. So it's an important question for your project.

Slide 27. Summary



Summary, take home points. The U.S. uses international basis for carbon accounting. It works well at the national scale and allows us to compare to other countries. The forest carbon stocks are relatively large across the U.S. so they can dwarf any small scale kind of disturbances, and you have to be aware of that when you're looking at disturbances in your area. There's uncertainties regarding all pools, and especially some of those nonlive tree pools, and we hope to improve in that in the future. These national carbon accounting protocols may provide a starting point and a context for your projects, and will fit into the subsequent talks that you see in this series.

Slide 28. Thank You!



So I'd like to thank you and take a question.

Footnotes

[1]DBH = diameter at breast height
[2]FIA=Forest Inventory and Analysis